Geologic Resource Evaluation Scoping Summary
Pecos National Historical Park, New Mexico

This report highlights a geologic resource evaluation scoping session that was held for Pecos National Historical Park in Las Vegas, New Mexico, on March 28, 2006. The NPS Geologic Resources Division (GRD) organized this scoping session in order to discuss the park's geologic resources, address the status of geologic maps and digitizing, and assess resource management issues and needs. Participants at the meeting included GRD staff, park staff, and cooperators from the New Mexico Bureau of Geology and Mineral Resources (NMBG&MR) and Colorado State University (table 1).

Table 1. Scoping Session Participants

Name	Affiliation	Phone	E-mail
Doug Bland	New Mexico Bureau of Geology and Mineral Resources (geologist)	505-466-6696	dbland@gis.nmt.edu
Tim Connors	NPS Geologic Resources Division (geologist)	303-969-2093	tim_connors@nps.gov
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Katie KellerLynn	Colorado State University (geologist/research associate)	801-364-1716	katiekellerlynn@msn.com
Ron Kerbo	NPS Geologic Resources Division (cave specialist)	303-969-2097	ron_kerbo@nps.gov
Virgil Lueth	New Mexico Bureau of Geology and Mineral Resources (geologist)	505-835-5140	vwlueth@nmt.edu

Tuesday, March 28, involved a welcome and introduction to the Geologic Resource Evaluation (GRE) Program, including the status of reports and map products. The morning's discussion focused on map coverage of the monument and other "quadrangles of interest" in the vicinity. In addition, Virgil Lueth (New Mexico Bureau of Geology and Mineral Resources) made an oral presentation about the geology of Pecos National Historical Park. Bruce Heise facilitated a group discussion regarding the geologic processes and features at Pecos National Historical Park. In the afternoon, attendees visited Pecos National Historical Park; Virgil Lueth highlighted the geology of the area at impromptu field trip stops. The visit also resulted in planning for an upcoming summer Association of American State Geologists (AASG) field trip to be hosted by the New Mexico Bureau of Geology and Mineral Resources is hosting.

Overview of Geologic Resource Evaluation Program

Geologic features and processes serve as the foundation of park ecosystems and an understanding of geologic resources yields important information for park decision making. The National Park Service (NPS) Natural Resource Challenge, an action plan to advance the management and protection of park resources, has focused efforts to inventory the natural resources of parks. Ultimately, the inventory and monitoring of natural resources will become integral parts of park planning, operations and maintenance, visitor protection, and interpretation.

The Geologic Resource Evaluation (GRE) Program, which the NPS Geologic Resources Division administers, carries out the geologic component of the inventory. Staff associated with other programs within the Geologic Resources Division (e.g., abandoned mine land, cave, coastal, disturbed lands restoration, minerals management, and paleontology) provide expertise to the GRE effort. The goal of the GRE Program is to provide each of the identified "natural area" parks with a digital geologic map and a

geologic resource evaluation report. In addition, the Inventory, Monitoring, and Evaluation Office of the Natural Resource Program Center is preparing a geologic bibliography for each of these parks. Each product is a tool to support the stewardship of park resources and is designed to be user friendly to non-geoscientists.

The scoping process includes a site visit with local experts, evaluation of the adequacy of existing geologic maps, and discussion of park-specific geologic management issues. Scoping will result in a summary (this document), which along with the digital geologic map, will serve as the starting point for the final GRE report. The emphasis of scoping is not to routinely initiate new geologic mapping projects but to aggregate existing information and identify where serious geologic data needs and issues exist in the National Park System. Scoping meetings are usually held for individual parks though some address an entire Vital Signs Monitoring Network.

Bedrock and surficial geologic maps and information provide the foundation for studies of groundwater, geomorphology, soils, and environmental hazards. Geologic maps describe the underlying physical framework of many natural systems and are an integral component of the physical inventories stipulated by the National Park Service in its Natural Resources Inventory and Monitoring Guideline (NPS-75) and the 1997 NPS Strategic Plan. The NPS geologic resource evaluation is a cooperative implementation of a systematic, comprehensive inventory of the geologic resources in National Park System units by the Geologic Resources Division; the Inventory, Monitoring, and Evaluation Office of the Natural Resource Program Center; the US Geological Survey; state geological surveys; and universities.

For additional information regarding the content of this summary, please consult the NPS Geologic Resources Division, located in Denver, Colorado. Up-to-date contact information is available on the GRE Web site at http://www2.nature.nps.gov/geology/inventory/.

The objectives of the geologic resource evaluation scoping meetings are as follows:

- To identify geologic mapping coverage and needs
- To identify distinctive geologic processes and features
- To identify resource management issues
- To identify potential monitoring and research needs

Outcomes of the scoping process include the following items:

- A scoping summary (this document)
- A digital geologic map
- A geologic resource evaluation report

Status of Scoping and Products

As of April 2006, the NPS Geologic Resources Division had completed the scoping process for 160 of 272 “natural resource” parks. Staff and partners of the GRE Program have completed digital maps for 68 parks. These compiled geologic maps are available for downloading from the NR-GIS Metadata and Data Store at http://science.nature.nps.gov/nrdata. The US Geological Survey, various state geological surveys, and investigators at academic institutions are in the process of preparing mapping products for 42 parks. Writers have completed 22 GRE reports with 18 additional reports to be completed by the end of fiscal year 2006.

Geologic Maps for Pecos National Historical Park

During the scoping session on March 28, 2006, Tim Connors (GRD) presented a demonstration of some of the main features of the digital geologic map model used by the GRE Program. This model incorporates the standards of digitization set for the GRE Program. The model reproduces all aspects of a paper map, including notes, legend, and cross sections, with the added benefit of being GIS compatible. GRE staff members digitize maps using ESRI ArcView/ArcGIS format with shape files and other features, including a built-in help file system to identify map units.

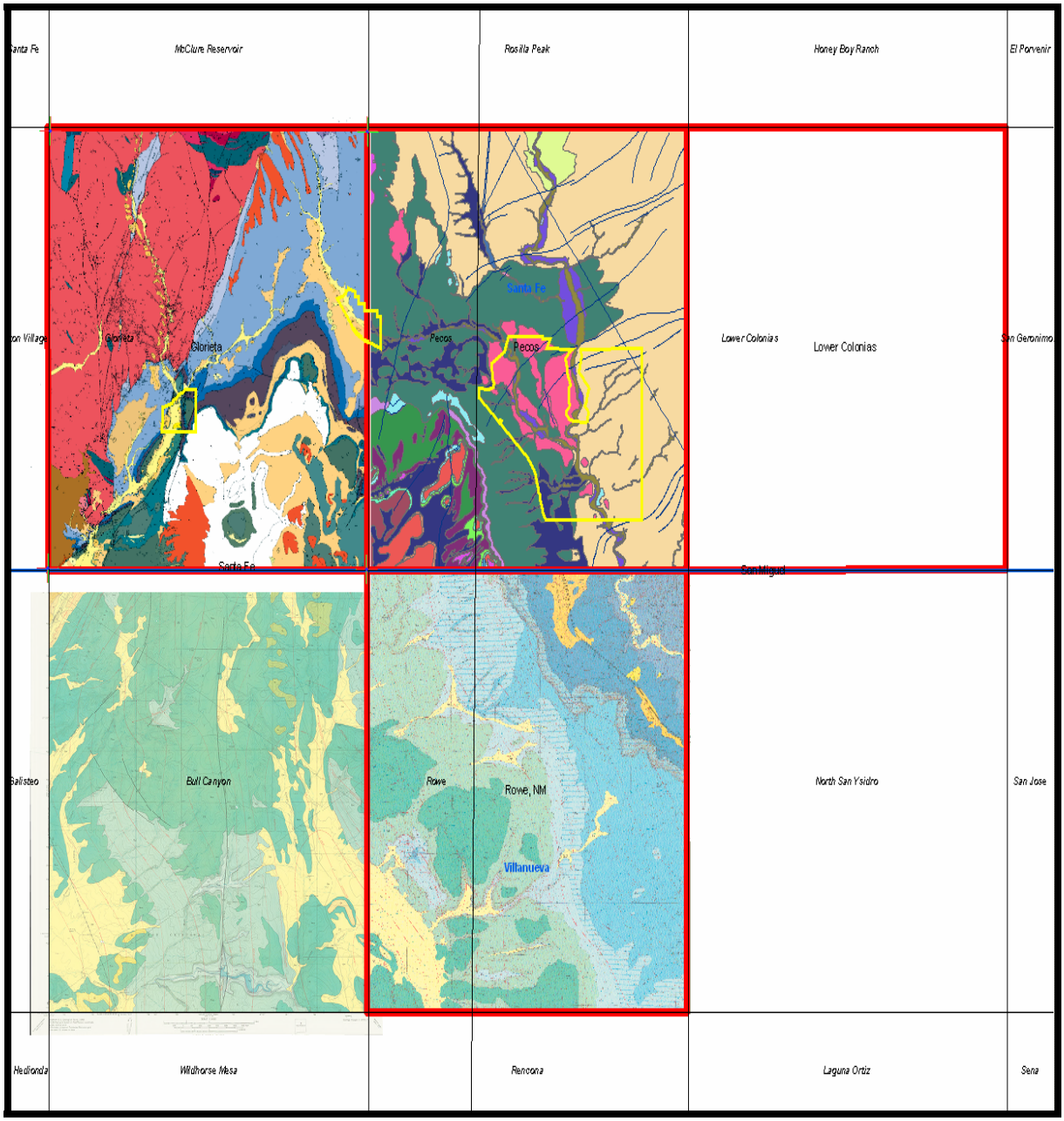

Figure 1. Quadrangles of interest for Pecos National Historical Park, New Mexico. Names in black indicate 7.5-minute quadrangles (scale 1:24,000); names in blue indicate 30-minute by 60-minute quadrangles (scale 1:100,000). Yellow outline indicates the boundary of the monument.

Parks in Inventory and Monitoring Network have identified "quadrangles of interest" mapped at one or more of the following scales: 7.5' × 7.5' (1:24,000), 15' × 15' (1:62,500), or 30' × 60' (1:100,000). Often

for simplicity, geologic map makers compile maps at scale 1:100,000 (30' × 60'), which provides greater consistency and covers more area. However, for the purpose of geologic resource evaluations, GRE staff would like to obtain digital geologic maps of all identified 7.5-minute (1:24,000-scale) quadrangles of interest for a particular park. The geologic features mapped at this scale are equivalent to the width of a one-lane road.

Table 2. Quadrangles of Interest for Pecos National Historical Park

Quadrangle	Map citation	Paper	Digital
GRE Plan: Convert NMBG&MR digital format to GRE digital format			
Glorieta	Ilg, B., Bauer, P.W., Ralser, S., Rogers, J., and Kelley, S., 1997, Geology of the Glorieta 7.5-minute quadrangle, Santa Fe County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Open-File Geologic Map OF-GM 11, scale 1:12,000 (GMAP 72954).*	No	Yes
Pecos	Read, A.S., and Rawling, G.C., 2002, Geology of the Pecos 7.5-minute quadrangle, San Miguel and Santa Fe Counties, New Mexico: New Mexico Bureau of Geology and Mineral Resources Open-File Geologic Map OF-GM 52, scale 1:24,000 (GMAP 6674).*	No	Yes
GRE Plan: Convert NMBG&MR digital format to GRE digital format (when available)			
Rosilla Peak	Melis, E., Bauer, P.W., and Goodwin, L.B., 2000 [unfinished], Geology of the Rosilla Peak 7.5-minute quadrangle, Santa Fe and San Miguel Counties, New Mexico: New Mexico Bureau of Mines and Mineral Resources Open-File Geologic Map OF-GM 31, scale 1:12,000.*	No	No
Do not digitize or convert			
McClure Reservoir	Bauer, P.W., Ralser, S., Daniel, C., Ilg, B., 1996, Geology of the McClure Reservoir 7.5-minute quadrangle, Santa Fe County, New Mexico: New Mexico Bureau of Geology and Mineral Resources Open-file Geologic Map OF-GM 7, scale 1:12,000.	n/a	n/a
Rowe	Johnson, R.B., 1972, Geologic map of the Rowe quadrangle, San Miguel and Santa Fe Counties, New Mexico: US Geological Survey Geologic Quadrangle Map GQ-1077, scale 1:24,000.	n/a	n/a
Lower Colonias	No map	n/a	n/a

*"GMAP" numbers are identification codes associated with the GRE database.

Map coverage for Pecos National Historical Park consists of four quadrangles of interest (scale 1:24,000): Lower Colonias, Pecos, Glorieta, and Rowe. The Lower Colonias, Pecos, and Glorieta quadrangles are situated on the Santa Fe 30' × 60' sheet; the Rowe quadrangle is situated on the Villaneuva 30' × 60' sheet (see figure 1 and table 2). The New Mexico Bureau of Geology and Mineral Resources produced the Glorieta quadrangle in 1997 and the Pecos quadrangle in 2002. Digital geologic data are available from the bureau for the Pecos and Glorieta 7.5-minute quadrangles. GRE staff has acquired ArcGIS files for the Pecos quadrangle and a "Freehand" version of the Glorieta quadrangle. GRE staff has the ability to convert the Pecos data but as of April 18, 2006, does not know how to use the "Freehand" data; hence, GRE staff may still need to digitize the Glorieta map from scratch.

Participants also evaluated the quadrangles to the north and south of the park. They determined that the Rowe quadrangle, south of the park, was of no particular interest from a resource management perspective. The two quadrangles to the north of the park are McClure Reservoir and Rosilla Peak. Pecos Creek flows from the north (Rosilla quadrangle) into the park; however, because the State of New Mexico monitors the water quality of the creek and a geologic map would probably not provide additional information regarding water quality, obtaining digital geologic maps of these two quadrangles is probably unnecessary. Nonetheless, if easily obtained, park staff would be interested in having the data associated

with the Rosilla Peak quadrangle. However, the Rosilla Peak quadrangle is presently "incomplete" (Mike Timmons, New Mexico Bureau of Geology and Mineral Resources, written communication, April 17, 2006). Moreover, the bureau is not currently mapping the Rosilla Peak quadrangle and does not plan to digitize this quadrangle until it is complete.

Geology of Pecos National Historical Park

Pecos National Historical Park is situated in a transition zone of three geophysical provinces: the Southern Rocky Mountains, Great Plains, and Basin and Range. In addition, the park occurs in a "cross zone" or accommodation zone of the Rio Grand Rift, which is a natural low area that native peoples and later settlers exploited. Though the park hosts the simplest geologic setting in the area, the coming together of these three provinces results in diverse geologic features in any direction from the park.

The development of the modern landscape is driven by a combination of geologic factors: (1) inherited geologic features, (2) imposed influences of modern tectonic forces, and (3) surface response to climatic variations and forces. The inherited geologic features include a zone of weakness developed billions of years ago during Proterozoic time. This zone of weakness, which geologists refer to as the Proterozoic discontinuity, represents an ancient assembly of the continent; it has been exploited throughout geologic time as the site of mountain-building events such as the Ancestral Rocky Mountains.

The rock layers of the park are horizontal with only minor structural undulations, the result of sitting on an anticline. The sediments that now form these rocks (shales and sandstone) were shed from the Ancestral Rocky Mountains. For example, the Sangre de Cristo Formation, a distinctive rock unit in the park, is a result of a migrating, meandering stream system; the red clay represents fluvial deposition, and the white sandstone represents deltas and beaches. Glorieta Mesa is a showcase of Sangre de Cristo and other rock formations:

- Santa Rosa Formation (Triassic)—yellow sandstone forming uppermost benches
- Moenkopi Formation (Triassic, 245 million years old)—grayish red sandstones (mostly covered)
- Artesia Formation (Permian)—orange siltstones (mostly covered)
- Glorieta Formation—yellow sandstone bench capping main escarpment
- Yeso Formation (Permian, <286 million years old)—reddish brown sandstones and siltstones
- Sangre de Cristo Formation (Pennsylvanian, >286 million years old)—lowermost grayish red and gray sandstones

Though not within the park's boundary, visitors can view Glorieta Mesa from the park. The mesa is easily interpreted because of the distinctive color variations of the rock units that comprise it, as well as the plants that selectively grow on the various layers.

Geologic Resource Evaluation Report

Geologic Resource Evaluation reports include sections about geologic resources of concern for management (referred to as "issues"), geologic features and processes, the park's geologic history, a map unit properties table that highlights the significant features and resource concerns for each map unit in the park, references (different from the bibliography), and various appendices (e.g., map graphics and scoping summary). This document (scoping summary) will serve as a starting point for information to be included in the final GRE report for Pecos National Historical Park, which will accompany the digital geologic map.

Geologic Features, Processes, and Issues at Pecos National Historical Park

The scoping session for Pecos National Historical Park provided the opportunity to capture a list of geologic features and processes operating in the park, which will be highlighted and expanded in the final GRE report. Some of these features and processes may be of management concern.

Streams
Gallisteo Creek, Glorieta Creek, and Pecos River run through Pecos National Historical Park. The Pecos River may have some water quality issues, but other agencies monitor the creek. The park's septic and lagoon system could affect water quality of the Pecos River.

Though flooding is not a concern for park infrastructure, fluvial erosion along creeks may be a concern for the preservation of cultural resources. Accelerated downcutting and narrowing of stream channels is changing the landscape at the park.

Hillslope Features and Processes
No infrastructure is affected by mass wasting processes. Slumping occurs primarily along the river corridors. In some areas, historic roads are sloughing away (e.g., Old Colonias Road) but mass wasting is not a park concern because these roads are not maintained.

Eolian (Windblown) Features and Processes
Periodic dust storms occur at Pecos National Historical Park; however, they are not a concern for resource management.

Seismic Features and Processes
Though participants at the scoping meeting did not identify any recent seismic activity in the area of the park, some follow-up may be warranted. The New Mexico Bureau of Geology and Mineral Resources has a catalog on seismic activity in the state. Allan Sanford at New Mexico Tech is in the process of updating this publication (Virgil Lueth, New Mexico Bureau of Geology and Mineral Resources, written communication, April 18, 2006). The current reference is as follows:

Sanford, A.R., Lin, Kuo-wan, Tsai, I., and Jaksha, L.H., 2002, Earthquake catalogs for New Mexico and bordering areas—1869–1998: New Mexico Bureau of Geology and Mineral Resources Circular 210, 104 p.

Paleontological Resources
Participants were not aware of any significant paleontological resources at the park; however, contacting the curator of paleontology, Dr. Spencer Lucas, at the New Mexico Museum of Natural History and Science may be worthwhile.

Disturbed Lands
Though miners extracted lead and zinc in the past, which may affect the water quality of Pecos Creek, no mining of large economic value has occurred within the park. During the scoping session, Ron Kerbo mentioned an abandoned mine land site, Baca Mine, which he inventoried for bat habitat. The mine was a natural opening that prospectors expanded. The mine has an adit and shaft, and was possibly a uranium or copper play. The Baca Mine poses some public safety concerns, though park staff has closed off the area with fencing and signs. Ron Kerbo would be willing to assist Dennis Ditmanson in preparing an inventory plan for the Baca Mine, which would include surveys of both natural and historical resources.

After the scoping session, Virgil Lueth conducted a basic literature search for documentation about the Baca Mine. He found a short discussion on the deposits in the area of the monument in Lindgren and others (1910) (see reference below), which discusses copper deposits in the Sangre de Cristo Formation in the area of the park. Virgil suspects that this is a reference to the Baca Mine. He found nothing in the more recent literature.

Lindgren, W., Graton, L.C., and Gordon, C.H., 1910, The ore deposits of New Mexico: US Geological Survey Professional Paper 68, p. 110–112.

In addition to the Baca Mine, gravel pits were exploited for the use of road base for the interstate highway. Most of these areas were reclaimed prior to the establishment of the park; however, park staff reclaimed one pit in the late 1990s.

In the past, heavy grazing occurred at Fort Lightning Ranch, which surrounds the park. In addition, ranchers conducted bulldozing and tree removal to “improve” rangeland.

Geologic Interpretation and Education

Park staff at Pecos National Historical Park often includes discussions of geology during interpretive walks, such as the “ruins tour.” Park staff discussed the possibility of Virgil Lueth training interpreters and conducting public field trips for visitors.